A Model for a Collaborative Lifecycle Space Mission Design Process

Stephen D. Wall
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena CA 91109 USA

Past space mission design methods emphasized performance-driven paradigms, with data return, cost and schedule being secondary issues. Now and in the future, costs are capped and schedules fixed, which requires that these two variables be treated as independent in the design process. Old concepts of risk aversion have now been replaced with risk awareness and management, thus creating another independent quantity. JPL has responded to this new world with a redesign of the design process itself based on two basic changes. First, design practices will be centered around concurrent teams and a design approach that considers all the core design variables together: what must it do, what must it cost, how much power, how much data, how much risk, etc. Second, sets of models will be used to confirm that these core variables are internally consistent. The models begin very simple and high level so that they can be used immediately. They progress to detailed models which are integrated and tested in the same way that the hardware and software will be tested when they are built. The models are linked through a design database to the foundry tools that produce hardware and software. Thus the old system of final assembly and test gives way to a new one where assembly and test start from the beginning.

At the conceptual (pre-award) level, design times can be reduced by properly defining the required design depth, understanding the linkages between tools, and through management of team dynamics. Design methodologies in implementation-phase design can be revised along similar lines, using a similar process. System requirements can be held in executable form, linked to subsystem design tools. Mission goals, which may be thought of as the rough equivalent of level-one system requirements, can be captured in timelining software that drives the models, testing their capability to execute the goals. The team dynamics revolve around use of three teams, each of which is managed in ways similar to those mentioned above.

Metrics are used to measure and control both processes and to ensure that design parameters converge through the design process within schedule constraints. Where traditional linear "waterfall" design methods require management of an ever-reducing margin as the design proceeds to an anticipated endpoint, this methodology manages margins controlled by acceptable risk levels. Thus, teams can evolve risk tolerance (and cost) as they would any engineering parameter. This new approach allows more design freedom for a longer time, which tends to encourage revolutionary and unexpected improvements in design. The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.